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TECHNOLOGY OF OBTAINING ESSENTIAL OIL EXTRACTS FROM SPICY AND AROMATIC RAW MATERIALS AND THEIR INFLUENCE ON MEAT AND FISH MOLDED READY-TO-COOK PRODUCTS

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Abstract

This work is devoted to the study of the process of extracting odorous substances of spicy and aromatic raw materials by maceration, with the establishment of technological parameters of the process (hydraulic module 1 : 5, duration – 10 days). The yield of extractives increases with increasing temperature, reaching a maximum at 40 °C, and then decreases. The highest yields (15.2 %) were found for the extract (cumin in combination with black pepper) and (barberry in combination with coriander). Phenolic compounds were isolated in all obtained essential oil extracts, the highest content was found in cardamom fruit – 4.43±0.14 mg/g. 21 recipes of meat and fish ready-to-cook products with different ratio (10–50 %) of meat (chicken fillet) and fish (hake, pollock, haddock, saithe) raw materials were developed, to which the obtained extracts were added. The results of organoleptic studies showed that the most optimal samples were those with the ratio of meat and fish (haddock) raw materials 50 : 50 % and meat and fish (saithe) raw materials 60 : 40 % respectively, using cardamom essential oil extracts and a mixture of rosemary and thyme. It was to these recipes of ready-to cook products that essential oil extracts in the amount of 2, 3, 5 and 8 % were further added. The highest scores in terms of taste and smell were given to molded meat and fish ready-to-cook products, which included an essential oil extract of a mixture of rosemary and thyme in the amount of 3 % by weight of raw mince. By fatty acid composition, the developed meat and fish molded ready-to-cook products of chicken fillet and haddock fish are closer to the scientifically based WHO standards. The shelf life of the ready-to-cook products is 8 days at a temperature of 4… –6°C.

Keywords: cardamom; rosemary; thyme; coriander, barberry, cumin, black pepper, maceration; essential oil extracts; meat and fish ready-to-cook products.

ТЕХНОЛОГІЯ ОТРИМАННЯ ЕФІРО-ОЛІЙНИХ ЕКСТРАКТІВ З ПРЯНО-АРОМАТИЧНОЇ СИРОВИНИ ТА ЇХ ВПЛИВ НА М'ЯСО-РИБНІ ФОРМОВАНІ НАПІВФАБРИКАТИ

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Анотація

Дана робота присв'ячена дослідженням процесу екстрагування пахучих речовин пряно-ароматичної сировини методом мацерації, з встановленням технологічних параметрів мацерації (гідромодуля 1 : 5, тривалості процесу 10 діб). Вихід екстрактивних речовин з підвищенням температури зростає, досягаючи максимуму за 40 °С, а потім зменшується. Найбільше значення виходу (15.2 %) встановлено для екстрактів №1 (кмин у поєднанні з чорним перцем) та №2 (барбарис у поєднанні з коріандром). Найвищий вміст за сумою фенольних сполук виділено в ефіроолійному екстракті з плодів кардамону. Розроблено 21 рецептуру м'ясо-рибних напівфабрикатів з різним співвідношенням м'ясної та рибної сировини. До рецептури входили: куряче філе, риба хек, мінтай, пікша, сайда у різних співвідношеннях від 10 % до 50 %. За результатами органолептичних досліджень встановлено, що оптимальними є зразки з використанням курячого філе та філе океанічної риби пікші, сайди у співвідношенні 50 : 50 % та 60 : 40 % відповідно. Саме до цих рецептур напівфабрикатів додавали п'ять отриманих ефіроолійних екстрактів з пряно-ароматичної сировини у кількості 2, 3, 5 та 8 % до рецептури. Найбільшу кількість балів за показниками «смак» і «запах» отримали зразки м'ясо-рибних напівфабрикатів до складу яких входили ефіроолійний екстракт суміші розмарину і чебрецю, доданий у кількості 3 % до маси сирого фаршу.

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В результаті досліджень даних зразків жирно кислотного складу встановлено, що у м'ясо-рибних формованих напівфабрикатах співвідношення м’яса та риби пікші 50 : 50 % є більш наближене до науково обґрунтованих норм. Термін зберігання м'ясо-рибних формованих напівфабрикатів складає 8 діб за температури – 4…–6°С.
Ключові слова: кардамон; розмарин; чебрець; мацерація; ефіроолійні екстракти; м’ясо-рибні напівфабрикати.

ТЕХНОЛОГИЯ ПОЛУЧЕНИЯ ЭФИРО-МАСЛЕНЫХ ЭКСТРАКТОВ ИЗ ПРЯНО-АРОМАТИЧЕСКОГО СЫРЬЯ И ИХ ВЛИЯНИЕ НА МЯСО-РЫБНЫЕ ФОРМИРОВАННЫЕ ПОЛУФАБРИКАТЫ

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Аннотация

Данная работа посвящена исследованию процесса экстрагирования пряно-ароматических веществ пряно-ароматического сырья методом мацерации, с установлением технологических параметров мацерации (гидромодуля 1 : 5, продолжительность процесса 10 суток). Выход экстрактивных веществ с повышением температуры возрастает, достигая максимума при 40 °С, а затем уменьшается. Наибольшее значение выхода (15.2 %) установлено для экстрактов №1 (тмин в сочетании с черным перцем) и №2 (барбарис в сочетании с кориандром). Наивысшее содержание по сумме фенольных соединений выделено в эфиромасличном экстракте из плодов кардамона. Разработана 21 рецептура мясо-рыбных полуфабрикатов с различным соотношением мясного и рыбного сырья. В рецептуру входили: куриное филе, рыба хек, минтай, пикша, сайда в разных соотношениях от 10 % до 50 %. По результатам предыдущих органолептических исследований установлено, что оптимальным оказались образцы с использованием куриного филе и филе океанической рыбы пикши, сайды в соотношении 50 : 50 % и 60 : 40 % соответственно. Именно к этим рецептурам полуфабрикатов добавляли пять полученных эфиромасличных экстрактов из пряно-ароматического сырья в количестве 2, 3, 5 и 8 % к рецептуре. Наибольшее количество баллов по показателям «вкус» и «запах» получили образцы мясо-рыбных полуфабрикатов, в состав которых входили эфиромасличный экстракт смеси розмарина и чабреца, добавленный в количестве 3 % к массе сырого фарша. В результате исследований данных образцов жирно-кислотного состава установлено, что в мясо-рыбных формованных полуфабрикатах соотношение мяса и рыбы пикши 50 : 50 % наиболее приближено к научно боснованным нормам. Срок хранения мясо-рыбных формованных полуфабрикатов составляет 8 суток при температуре – 4…-6 °С.
Ключевые слова: *кардамон; розмарин; тимьян; мацерация; экстракты эфирного масла; мясо-рыбные полуфабрикаты.*

Introduction

The search for effective biological products of natural origin possessing biological and antioxidant activity against oxidative processes in lipids of meat products is an important production task [1].

The use of biologically active substances in the form of natural ingredients of various compositions is of undoubted interest around the world. A promising type of plants that are already used abroad to produce essential oil is spicy aromatic raw material [2]. The production of combined additives, which are mixtures of aromatic extracts, emulsifiers, preservatives, phosphates, is highly relevant. Today, the taste and aroma of food products is achieved through the use of specially designed mixtures of natural essential oils and extracts from spices and spicy and aromatic plants dispersed on a food carrier [3]. In foreign and domestic practice, there are a large number of multifunctional additives of plant origin, which combine the ability to improve the antioxidant and flavoring properties of finished products [4]. In particular, plant extracts of rosemary [5], cardamom [6], thyme [7] and medicinal plants [8] are used. Currently, on an industrial scale for the processing of such raw materials maceration is used, i.e. extraction of odorous substances with vegetable oils or melted fats without raising the temperature and subsequent removal of the extractant [9]. The main task in the production of biologically active additives of natural plant raw materials is to obtain oil extracts while preserving their biological properties, without subjecting them to temperature or chemical treatment [10].

Despite the available studies of the antioxidant activity of spicy and aromatic raw material extracts in relation to meat products, the issue of fat oxidation and reduction of shelf life of meat and fish ready-to-cook products is not sufficiently covered, as fish by its nature has increased moisture content inherent in fish raw materials. There are no meat and fish ready-to-cook products in the trade network of Ukraine, as well as information on the use of saithe and haddock in the production of combined ready-to-cook products. There is no data on the storage of such products. Therefore, there is a need for research in this direction.

Fish and seafood are in great demand among consumers. Fish protein is balanced in amino acid content, rich in leucine – 3.9–18.0 %, isoleucine - 2.6–7.7 %, phenylanine 1.9–14.8 %, methionine 1.5–3.7 %, and threonine 0.6–6.2 % [11]. Fish contains long-chain ω –3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), the latter plays a significant role in the formation of the brain and vision of the child and is useful for blood circulation. There are also fat-soluble vitamins (E and D), low molecular weight metabolites such as anserine and taurine. Due to such fatty acid composition, the consumption of fish and fish products has a number of benefits for human health, playing a potential role in reducing the risk of coronary heart disease, inflammatory and immune disorders [12].

According to the State Statistics Committee of Ukraine, per capita consumption of fish and fish products in 2019 was only 14.5 kilograms [13]. However, the recommended FAO norm should be 20 kg [14], and marine fish should be 75 % of the established norm. Currently, Ukraine imports close to 90 % of fish [15]. This situation is due to the lack of a specialized fleet, quotas in international waters and poaching. In addition, the cost of Ukrainian fish is higher than of the imported. The traditional leaders in fish imports to Ukraine are Norway, followed by the USA, Estonia, Latvia, Canada, Great Britain, China, Vietnam and Argentina [16]. Ocean haddock and saithe fish come to Ukraine from Norway in the form of carcasses, fillets and trimmings.

The pace of modern life requires a significant amount of time to prepare fish for consumption [17], perhaps because of that 42 % of European consumers eat fish and seafood at least once a week [18]. Young people prefer fish ready-to-cook products - cutlets, fish balls, fish burgers [19]. The development of fish-based foods for the elderly people is equally important. Such products not only meet the physiological needs of the human body in nutrients and energy, but also have preventive and curative functions [20]. The development of products for geriatric-oriented diet will contribute to reducing the number of diseases of the elderly people [21; 22].

The analysis of foreign and domestic researches shows that there is ample room for the use of ocean fish in technology of special products for various layers of the population, expansion of their range, establishment of their shelf life [23; 24]. To produce a pilot batch of meat and fish ready-to-cook products, we took poultry as the most available raw material for Ukrainian consumers, and fish: pollock, hake, haddock and saithe with the addition of essential oil extracts from spicy and aromatic raw materials.

The purpose of our study is the technology of extraction of essential oil extracts from spicy and aromatic raw materials, and the establishment of technological parameters that ensure the optimal yield of extractive substances (hydromodule, duration of extraction). Investigation of the effect of essential oil extractive changes in the fatty acid composition of meat and fish molded ready-to-cook products during storage. Study of the effect of essential oil extracts on the change of fatty acid composition of meat and fish molded ready-to-cook products during storage. In this regard, to solve this goal it is necessary to perform the following tasks:

- to study the process of extraction of fragrant substances with vegetable oils or melted fats and to evaluate the consumer properties of the obtained essential oil extracts;
- optimize the technological parameters of the maceration with liquid oil, with the establishment of extraction duration;
- study the organoleptic and physicochemical characteristics of the obtained essential oil extracts of spicy and aromatic raw materials with their subsequent use in the technology of meat and fish molded ready-to-cook products;
- establish antioxidant properties of the essential oil extracts of spicy and aromatic raw materials by content of phenolic compounds;
- study changes in fatty acid composition of meat and fish molded ready-to-cook products prepared with the use of essential oil extracts of spicy and aromatic raw materials during their storage.

Object of research: technology of obtaining essential oil extracts and their mixtures from spicy and aromatic raw materials and their effect on meat and fish molded ready-to-cook products.

Subject of research: mixtures of essential oil extracts of spicy aromatic raw materials, namely cumin in combination with black pepper, barberry in combination with coriander, coriander in combination with black pepper, rosemary in combination with thyme and cardamom; meat and fish molded ready-to-cook products.

Experimental part

The appearance, color, and odor of the essential oil raw materials were determined by examining a sample placed in a thin even layer on a glass slide or sheet of white paper. Density was determined in accordance with DSTU ISO 279-2002 "Essential oils. Determination of relative density at a temperature of 20 ° C. Control method (ISO 279:1998, IDT)" using a pycnometer.

The refractive index and the content of extractives were determined according to DSTU ISO 6320-2001 "Animal and vegetable fats and oils. Determination of refractive index (ISO 6320:2000, IDT.)". The quantitative content of the sum of phenolic compounds was determined by permanganatometric titration.

The fatty acid composition of the test samples was determined by gas chromatography GOST 55483-2013 "Meat and meat products. Determination of the fatty acid composition by gas chromatography", i.e. the liquid extraction of animal lipids was performed with organic solvents, that makes it possible to isolate 90% - 95% of all cellular lipids, and methylation of lipid triglycerides by hydrolysis, followed by the conversion of the obtained fatty acids into methyl esters. The chromatographic analysis of the mixtures was performed on an automatic gas chromatograph with a flame ionization detector to determine the composition and the mass fraction of fatty acids.

Research results and their discussion

At the first stage of research we performed maceration, i.e. extraction of fragrant substances with vegetable oils. The rate and completeness of extraction were influenced by factors such as the degree of grinding of the raw material, the difference in concentration, temperature, the viscosity of the extractant, the duration of extraction.

To facilitate the diffusion process, the raw material must be ground. By this a significant increase in the contact surface between the particles of raw materials and extractant is achieved. According to the law of diffusion, the larger the contact surface, the greater the amount of extracted substance is. A fairly high difference in concentrations at the phase separation boundary can be maintained by stirring the mass, frequent replacement of the extractant (for example, by remaceration), countercurrent process, etc. Raising the temperature accelerates the extraction process. However, in the conditions of production heating is used only during extraction with water. As the viscosity of the extractant decreases, the diffusion coefficient increases and, therefore, less viscous liquids promote faster extraction. Therefore, when using viscous extractants, such as vegetable oils, to accelerate the extraction process, heating the extractant is carried out. As the extraction time increases, the amount of extracted substance increases, too. An important task of the research is to establish technological parameters that ensure the optimal yield of extractives. In determining them, the experiment was based on a second-order plan, i.e. Box–Behnken design with the number of independent variables m = 2.

Knowing the maximum and minimum limits of technological modes that affect the development of technology for oil production, the influence of the following factors was investigated:

- hydraulic module (using deodorized sunflower oil: cardamom fruit) – from 1 : 5 to 1 : 10;
- duration of extraction - from 3 to 10 days.

The plan of the experiment is shown in Table 1.

Table 1

Experiment plan

№	X_0	Hydraulic module, x_1		Duration, x_2		Optical density of the extract, λ 353 nm, y_1
		conditional	%	conditional	days	
1	+1	+1	0,2	+1	10	0.690
2	+1	-1	0,1	+1	10	0.619
3	+1	+1	0,2	-1	3	0.797
4	+1	-1	0,1	-1	3	0.713

The basic level x^0j and intervals of variation Δx are given in Table 2

Table 2

Basic level and intervals of variation of variables in the plan

	Factors	
	Hydraulic module, x_1	Duration, x_2, days
Basic level, x^0_j	7.5 : 1	6.5
Intervals of variation, Δx	2.5	3.5

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The optical density of the extract at wavelength λ 353 nmy_1 was chosen as a response function.

For the possibility of statistical processing, all experiments were performed in three parallels. The results are presented as an arithmetic mean, which was calculated by the formula:

$$\dot{y} = \frac{\sum_{u-1}^{m} yu}{m},$$

where y_u- response function in parallels; m - number of parallel measurements.

The optical density of the oil extracts was determined in the wavelength range from 310 to 700 nm. The results of the spectrophotometric study are shown in Fig. 1.

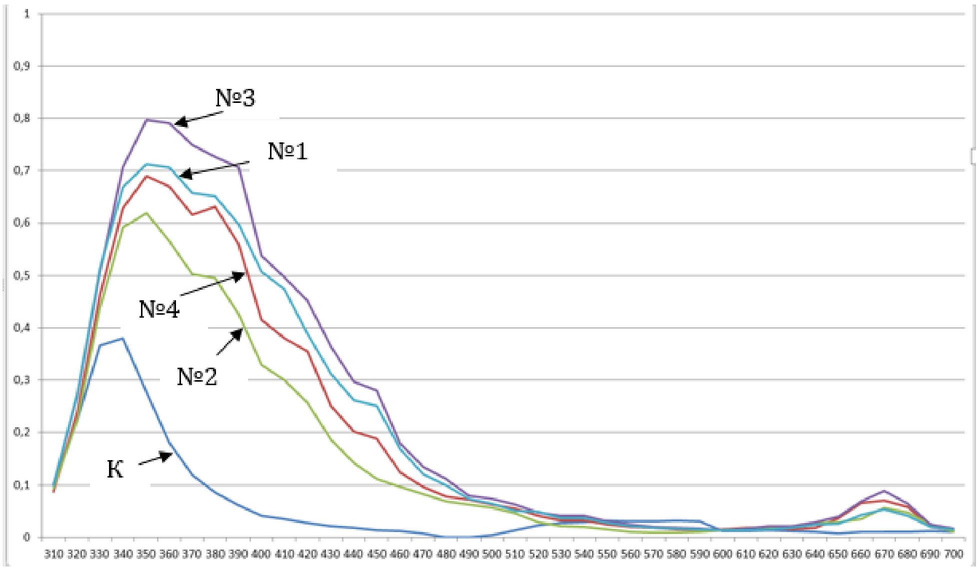

Fig. 1. Optical density of essential oil extracts in the range from 310 to 700 nm
№ 1– hydraulic module 1: 5, process duration 3 days; № 2 - hydraulic module 1:10, process duration 3 days; №3– hydraulic module 1: 5, process duration 10 days; №4 – hydraulic module 1:10, process duration 10 days; K - extractant.

Figure 1 shows that the spectra of samples №1 and №3 are higher than those of samples №2 and №4, which indicates a greater efficiency of the extraction process. The revealed pattern is well visible when comparing the absolute values of the optical density obtained at a wavelength of 353 nm (Table 1). According to the graph in Fig. 1, it can be concluded that at a hydraulic module of 1: 5, higher values of optical density were obtained over the entire range of the studied waves.

Another factor in this study is the duration of the maceration process. It was found that the values of the optical density of the studied extracts are higher in samples №3 and №4, which were obtained during extraction for 10 days.

As a result of mathematical processing and exclusion of insignificant coefficients, the regression equation is represented as:

$$y1 = -31{,}24 + 2{,}21x1 + 2{,}29x2 * 0{,}01x12 - 0{,}21x22 + 0{,}25x1x2$$

The hypothesis about the adequacy of the equation was accepted under the conditions that the experimentally obtained value of the Fisher coefficient is less than the tabular one.

Verification by Fisher's test at a significance level of α = 0.05 showed that the obtained equation is adequate to the experiment.

Based on the results of research, it is clearly revealed that with increasing process duration and decreasing hydromodule, the value of optical density increased at the appropriate wavelength range. Therefore, the most effective technological parameters for the extraction of oil extracts from spicy and aromatic raw materials by maceration are hydromodule 1 : 5 and process duration of 10 days.

In the second stage of research, the effect of temperature on the extraction rate was established. A characteristic feature of the extraction processes from spicy and aromatic raw materials is the considerable duration of the process. The reason for this is the cellular structure of organic tissue, in particular the presence of a cell wall, the physiological state of which slows the excretion through the porous structure of the solid body. Among the factors influencing the speed of internal diffusion processes, and this is the mechanism of most extraction processes from spicy and aromatic raw materials, the temperature is the most important. The rate of the extraction process is the change in concentration of the target substance in the extractant per unit time.

In maceration technology, extraction with vegetable oils is performed using heat, but for thermolabile substances, the use of heated extractant is permissible only for a short time.

According to the semi-empirical Vant-Goff rule, the rate of a chemical reaction increases 2-4 times for every 10° C increase in temperature. Therefore, it was reasonable to find out the change in the rate of diffusion processes, in particular intradiffusion processes of extraction of spicy and aromatic raw materials when the temperature is increased by 10 degrees. We investigated the yield of extractive substances in five oil extracts of mixtures of spicy and aromatic raw materials during maceration for 6 hours at different temperatures. The results are given in Table 3.

Table 3

Influence of temperature on the yield of extractives (τ = 6 hours, n=3, P=95%)

№	Name of the sample	The content of extractives in the extracts, %				
		20 °C	30 °C	40 °C	50 °C	60° C
1	Cumin combined with black pepper	10.6 ± 0.2	11.9 ± 0.4	15.2 ± 0.2	13.1 ± 0.6	10.1 ± 0.2
2	Barberry combined with coriander	10.1 ± 0.3	11.9 ± 0.7	15.2 ± 0.1	14.8 ± 0.6	14.1 ± 0.2
3	Coriander combined with black pepper	12.5 ± 0.6	15.8 ± 0.9	10.1 ± 0.4	10.1 ± 0.1	7.2 ± 0.9
4	Rosemary combined with thyme	10.8 ± 0.3	11.9 ± 0.5	13.2 ± 0.6	12.9 ± 0.4	11.5 ± 0.3
5	Cardamom	10.7 ± 0.4	10.8 ± 0.6	14.6 ± 0.2	14.5 ± 0.2	13.2 ± 0.6

Table 3 shows that the dynamics of the extraction is almost the same for all samples studied. Analysis of the experimental values shows that in all samples with increasing temperature up to 40 ° C the speed of the extraction process increases and then decreases. The yield of extractives increases with increasing temperature, reaching a maximum at 40 ° C, and then decreases. The highest yield values (15.2%) were found for extracts №1 (Cumin in combination with black pepper) and №2 (Barberry in combination with coriander). Somewhat inferior to them is extract №5 of cardamom fruit, its maximum concentration being 14.6 % at 40 °C. The decrease in the rate of the extraction process at all investigated temperature values can be explained by a decrease in the driving force or the useful concentration difference in the solid and liquid phases. A significant increase in temperature is not always advisable, because it leads to a change in the properties of most biologically active compounds contained in the spicy and aromatic raw materials.

According to Tsimogiannis D., phenolic compounds are the most common class of biologically active substances of plant origin [25]. Ligor M. and Valderrama F. note that phenolic compounds of plant origin are able to neutralize free radicals, reactive oxygen species and products of their interaction with organic molecules, as well as exhibit antimutagenic activity [26; 27]. According to Christaki E. and Khani M., polyphenols maintain the oxygen supply of tissues at the optimal level and prevent the negative impact of environmental factors [28; 29].

Antioxidant properties of essential oil extracts are determined by their chemical composition, so it is important to quantify the content of phenolic compounds in the obtained extracts (table 4).

Table 4

The content of phenolic compounds

№	Name of the sample	The content of phenolic compounds, mg / g
1	Cumin combined with black pepper	2.87±0.14
2	Barberry combined with coriander	2.22±0.12
3	Coriander combined with black pepper	3.91±0.12
4	Rosemary combined with thyme	2.11±0.12
5	Cardamom	4.43±0.14

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As can be seen from table 4, all test samples contain phenolic compounds, but in different amounts. The highest content of the sum of phenolic compounds was isolated in the essential oil extract from cardamom fruits. The extract № 3 (Coriander in combination with black pepper) is slightly inferior to it in terms of the content of phenolic compounds, and their content is lower in the rest of the studied samples. Polar phenols, such as tocopherols and lignins, are antioxidants that prevent oxidation of membrane lipids and increase the stability of fats and oils during storage and heating. Antioxidant activity of phenolic compounds is explained by the fact that they bind heavy metal ions into stable low-active complexes, as well as serve as acceptors formed during autotoxification of free radicals, i.e. phenolic compounds can quench free radical processes.

At the next stage of research we developed 21 recipes for meat and fish ready-to-cook products with different ratios of meat and fish raw materials. The recipes included: chicken fillet, hake, pollock, haddock, saithe in various ratios from 10 % to 50 %. We studied the effect of obtained essential oil extracts on the change in the fatty acid composition and the storage time of molded meat and fish ready-to-cook products with different content of meat and fish raw materials.

According to the results of preliminary organoleptic research it was found that the most optimal were samples using chicken fillets and oceanic fish fillets of haddock and saithe in the ratio of 50:50% and 60:40% with extracts of cardamom and a mixture of rosemary and thyme. It is to these recipes of ready-to-cook products that the essential oil extracts in the amount of 2, 3, 5 and 8 % to the mass of the recipy were subsequently added. The highest scores in terms of taste and smell were given to meat and fish ready-to-cook products with an essential oil extract mixture of rosemary and thyme in the amount of 3% to the mass of raw minced meat. Therefore, these samples were selected for further studies on the shelf life and changes in the fatty acid composition (Table 5).

Table 5

Recipes of meat and fish molded ready-to-cook products selected for further research

Raw material	Recipe option		
	Control TU 9214-021-51361389-2002	Sample 2.1 50 : 50	Sample 2.2 60 : 40
Chicken fillet	53.7	26.85	32.2
Haddock fish, g	-	26.85	-
Saithe fish, g		-	21.25
Bread, g	11.2	11.2	11.2
Melange, g	5.5	5.5	5.5
Onions, g	11.2	11.2	11.2
Salt, g	1.2	1.2	1.2
Pepper, g	0.1	0.1	0.1
Breadcrumbs, g	4.0	4.0	4.0
Water, g	13.0	6.5	7.8
Essential oil extract of a mixture of rosemary and thyme	-	3	3

An important factor in dietary adjustments is to develop a product that is balanced in both amino acid and fatty acid composition. The ratio of fatty acids is one of the indicators of the biological and nutritional value of fats. The chromatographic analysis of R-fatty acid composition allows us to evaluate the origin and quality of fats in a particular product. The results of studies of the fatty acid composition of meat and fish ready-to-cook products are shown in Table 6.

Table 6

Fatty acid composition of meat and fish molded ready-to-cook products

Fatty acids	Code name	Sample 2.1, g/100 g of fat	Sample 2.2, g/100 г of fat
UFA			
Caprylic	C 8:0	-	0.018822
Caprine	C 10:0	0.020608	0.018423
Laurin	C 12:0	0.028847	0.038310
Myristic	C 14:0	0.259243	0.295821
Pentadecyl	C 15:0	0.039914	0.047443
Palmitic	C 16:0	11.512156	11.551927

Continuation of the table 6

Margarinic	C 17:0	0.113642	0.123330
Malvic	C 17:1	0.072686	0.055142
Stearic	C 18:0	4.367572	4.385838
Arachic	C 20:0	0.175453	0.219073
Begenic	C 22:0	0.403112	0.445642
Lignoceric	C 24:0	0.113672	-
MUFA			
Myristoleic	C 14:1	-	0.021349
Palmitooleic	C 16:1n9	0.236337	0.213031
7-hexadecanoic	C 16:1n7	0.876054	0.884336
6-octodecenoic (oleic)	t-C 18:1	0.167470	0.074597
9-octodecenoic (elaidic)	C9-C18:1	30.393462	31.659275
11-octodecenoic (cis-vacetic)	C11-C18:1	1.539969	-
Nervonic	C 24:1n9	0.046485	-
PUFA			
Linoleic	C 18:2	0.111492	0.125825
γ-Linolenic	9c,12c-C18:2n6	48.043178	47.782497
α- Linolenic	t-C 18:3n3	0.033161	0.320696
9-eicosanic (codoleic)	C9-C 20:1	0.235986	0.324210
Genicosanic	C11,14-C 20:2	0.093784	0.109124
Digomo-γ-linolenic	C 20:3n6	0.066952	0.454636
Arachidonic	C 20:4n6	0.416071	0.073209
Thymnodonic	C 20:5n3	0.064564	0.191961
Clupanodonic	C 22:5n3	0.025086	-
Cervonic	C 22:6n3	0.191596	0.445520
Total		100.000000	

Modern requirements for the fat component of the diet state that an adult's daily intake (80–100 g, including 20–25 g of vegetable fats) should contain 2-6 g of polyunsaturated fatty acids, 35 g of oleic acid, and 20 g of saturated fatty acids. According to Peshuk L.V., special attention should be paid to two groups of polyunsaturated fatty acids, ω3 and ω6, which are necessary for human growth and development and also perform an immunomodeling role [30].

The content of unsaturated fatty acids (linoleic, linolenic, arachidonic) in the fat of freshwater fish ranges from 6 to 30 %, in the fat of marine fish – from 13 to 57% of the total amount of fatty acids. Fish oil is characterized by the presence of unsaturated fatty acids with an increased number of double bonds: linolenic $C_{17}H_{29}COOH$ (three double bonds), arachidonic $C_{19}H_{31}COOH$ (four double bonds), clupanadonic $C_{21}H_{33}COOH$ (five double bonds). Unsaturated fatty acids form the basis of fish oil (up to 84 % of total fatty acids), which is due to its rare consistency and easy digestibility.

Table 7

Ratio of fatty acids in developed meat and fish ready-to-cook products

Samples	Content, g/100 g of fat			Ratio		
	MUFA	PUFA	UFA	UFA: PUFA: MUFA	PUFA: MUFA: UFA	MUFA: PUFA: UFA
Sample 2.1	33.259717	49.28187	17.219061	1:0.4:0.5	1:1.5:2.8	1:0.7:1.9
Sample 2.2	32.852588	49.827674	17.199771	1:0.3:0.5	1:1.5:2.9	1:0.6:1.9

In the human body, food fat has two functions: non-specific, as a source of energy, and specific, as a source of essential fatty acids and fat-soluble vitamins, and as material for biosynthesis and construction of body fat tissues. Such a balanced diet is realized by including 1/3 plant fats and 2/3 animal fats in the diet.

Sample 2.1 of meat and fish molded ready-to-cook products has a ratio of fatty acids UFA : PUFA : MUFA = 1,0 : 0,4 : 0,5, which is closer to the scientifically based standards in comparison with Sample 2.2 UFA : PUFA : MUFA = 1 : 0,3 : 0,5. The ratio of PUFA : MUFA : UFA is almost indistinguishable in the samples given.

Unsaturated fatty acids are part of the acylglycerols of almost all known fats in one quantity or another. In animal fats, palmitic and stearic acids have the highest content, which is

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confirmed by the results of chromatographic studies of fatty acid composition, carried out in the laboratory of the State Enterprise "Ukrmetrteststandart" (Table 8).

Table 8

Mass fraction of palmitic and stearic acids to the total amount of unsaturated fatty acids

Sample name	Mass fraction, %
Sample 2.1	92,22
Sample 2.2	92,66

At the same time, due to the high amount of unsaturated fatty acids, fish oil is easily oxidized, which is accompanied by accumulation of oxidation products (peroxides, hydroperoxides) and decomposition products (aldehydes, ketones, low molecular weight fatty acids, alcohols, etc.), which significantly worsen the taste and smell not only of fat, but of fish products, and are also toxic elements for human body [31].

Lipid oxidation of finished products includes undesirable changes in organoleptic characteristics during the guaranteed shelf life. In addition to oxidation of fats the reduction of shelf life may be due to the increased moisture content, which is inherent in the fish raw materials included to the recipes of meat and fish ready-to-cook products.

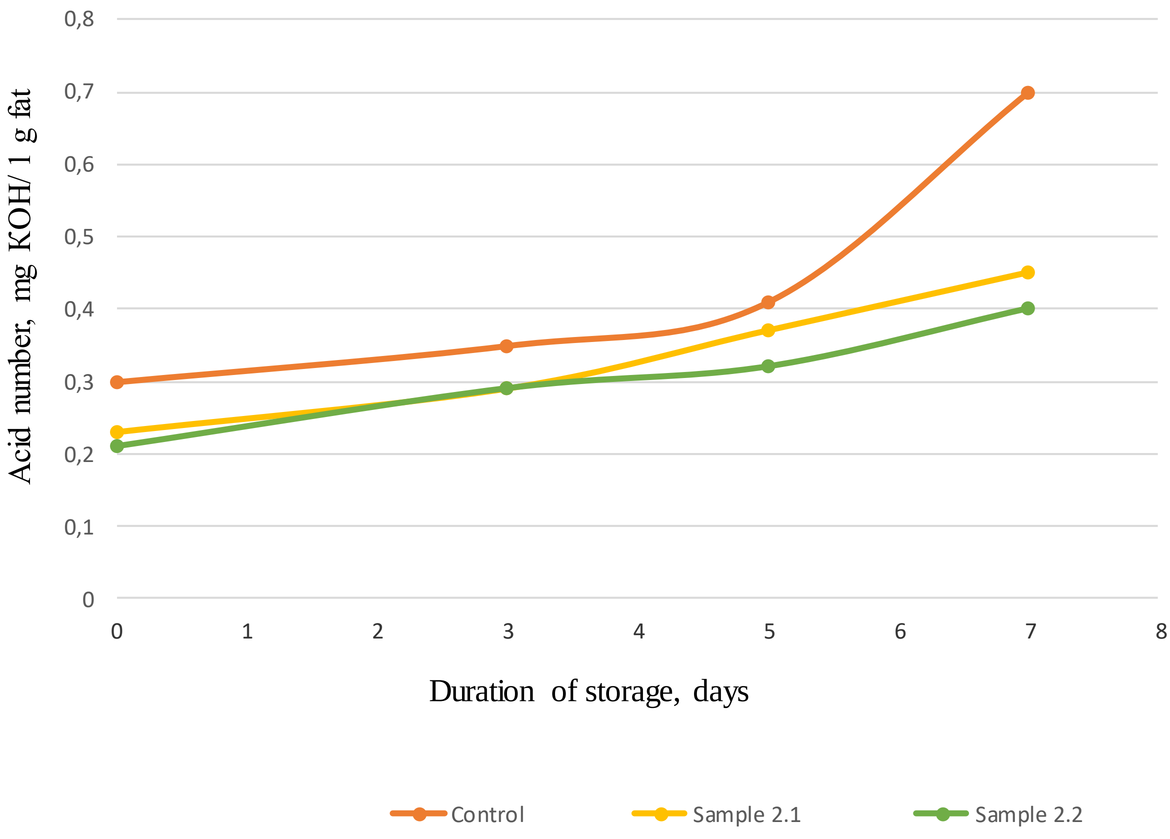

Fig. 2. Dynamics of changes in the acid number of meat and fish ready-to-cook products, mg KOH / 1 g fat

Frozen meat and fish molded ready-to-cook products were stored at temperatures no higher than 4...–6°C for 8 days. Since there are no standardized values of oxidative deterioration indicators for meat and fish ready-to-cook products, the limit values for the acid number, at which the fat is considered suitable for consumption, were selected on the basis of the average value of the established standards for melted fats and fish oil. Since the ratio in the experimental samples of meat and haddock fish is 50:50, and of meat and saithe fish is 60 : 40, the acid number for meat products when determining the limit values was calculated taking into account its fat content:

- melted fats – not more than 1.1 mg KOH/g fat, recalculated to 1 kg of product, taking into account its fat content according to GOST 25292-82.

- fish oil – not more than 4.0 mg KOH/g fat recalculated to 1 kg of product, taking into account its fat content according to TR TS 021/2011.

Fig. 2 shows that the inhibition of lipid oxidation during storage occurs when the essential oil extracts of rosemary and thyme mixture are introduced into the mince. The obtained results of the dynamics of changes in the acid number of the developed meat and fish ready-to-cook products did not exceed the limit values. This is explained by the fact that the spicy and aromatic plants chosen for the study contain phenols, crystalline thymol and liquid carvacrol and terpenes: cymol, borneol, cingiberin, terpin, terpineol. Due to this chemical composition of spicy and aromatic plants, their use in the technology of meat products can increase the shelf life of finished products.

Conclusions

The results obtained allow us to confirm the influence of the main technological factors on the yield, composition and dynamics of extraction of essential oil extracts from spicy and aromatic raw materials, namely that with increasing the process duration and decreasing the hydromodule the process efficiency increases. The maximum yield of extractive substances was at 40 °C, and it decreased with subsequent increase in temperature. The content of phenolic compounds in all extracted essential oil extracts from spicy and aromatic raw materials has been established. The highest content was obtained in the essential oil extract from cardamom fruits - 4.43±0.14 mg/g.

As a result of comparative analysis of organoleptic indicators, we selected for for further research meat and fish molded ready-to-cook products using fillets of chicken and haddock fish in a ratio of 50:50% and using fillets of chicken and saithe fish in a ratio of 60:40%, in which the essential oil extracts of rosemary and thyme mixture in an amount of 3% to the mass of raw mince was introduced.

As a result of studies of fatty acid composition it was found that in meat and fish molded ready-to-cook products the ratio of meat and haddock fish 50:50% is closer to the scientifically based norms of the WHO.

Shelf life of meat and fish molded ready-to-cook products is 8 days at -4...-6 ºC, as during this period the dynamics of changes in the acid number did not exceed the limits of the established standards for melted fats and fish oil.

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